Potatoes For LIVESTOCK FEED

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Preface

The information contained in this report relates to the research completed by State experiment stations, colleges of agriculture, and others on feeding potatoes to livestock. The purpose of summarizing these data is to encourage a wider use of potatoes as livestock feed during periods when supplies exceed demand for food use.

The Fruit and Vegetable Branch has undertaken no experimental research in this field. However, since it is believed that many potato growers and livestock feeders are unaware of the potential value of potatoes as feed, the Fruit and Vegetable Branch has prepared this report as a handy reference to the results of feeding tests in various parts of the country, with different classes of livestock and with varied rations for each class.

The underscored numbers in parenthesis throughout the text indicate the sources of the material. Those interested in making a more complete study may obtain these publications from a library, or possibly by writing the author or publisher.

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This report has been prepared under authority of the Research and Marketing Act of 1946.

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POTATOES FOR LIVESTOCK FEED

Introduction

Since enactment of the Steagall Amendment of July 1, 1941, 1/ into law, the price-support program for potatoes has brought to public attention problems that have confronted potato growers for many years. During large crop years before the inauguration of the price-support program, growers either failed to harvest a part of their crops or they dumped a quantity of potatoes at the end of the marketing and storage season. Some of the remaining potatoes were fed to livestock. The development of economic outlets for low-grade and surplus potatoes is of vital importance to the industry; and the recent focusing of public attention on the need for governmental removal of surplus potatoes is giving new life to the search for such outlets.

This report outlines the value of potatoes for livestock feed. It is designed to serve also as a handy guide for livestock feeders and potato growers by summarizing the major research work that has been completed or has progressed sufficiently to permit a useful report.

Economic Factors

Every year a substantial quantity of the potato crop is found to be unsuitable for human food or for seed. The quantity varies greatly from place to place and from year to year, according to changes in weather, growing conditions, and production and handling practices. It is estimated from various trade reports and data available in the United States Department of Agriculture that 10 to 20 percent of the national production each year, or, on an average, about 50 million bushels should be classed as culls and unsuitable for human consumption. From the estimated utilization of the crop, it appears that approximately half of this quantity is moved into commercial channels. The remainder includes shrinkage, waste, and the quantity fed to livestock or otherwise used on the farm where grown.

1/ 55 Stat. 498 (1941); 56 Stat. 768 (1942); 15 U.S.C. 713a-8(a), Supp. IV.

This publication supersedes an unnumbered mimeographed release of February 1948.

An effective merchandising program is necessary in order to prevent a further decline in national potato consumption. However, such a program has little likelihood of success unless better marketing practices are adopted. The potato industry as a whole should benefit materially by marketing only a product of superior uniform quality. Shippers of table stock potatoes should grade out all poor quality and small potatoes. Shippers of seed potatoes should follow more careful selection practices because seed quality is most important.

The demand for potatoes is highly inelastic. Historically, this characteristic has given rise to the major economic problems of the potato industry. On the basis of an analysis of production and farm price data as published by the Bureau of Agricultural Economics during the period 1920 to 1941, an increase of approximately 7 percent (about 25 million bushels) in supply is generally associated with a decline of about 20 to 25 percent in potato farm prices. Very little increase in the proportion marketed is associated with a disporportionate reduction in price. The returns to the shipper from the sale of culls and pick-outs normally cover little more than the cost of sacking and loading. If sales of culls and pick-outs cause a significant decline in the price of the higher grades by increasing the total supply of potatoes in the terminal markets, the transaction is highly uneconomical and unprofitable for the industry.

Alternative outlets, of which livestock feed is one, should be increased to absorb an important part of the low-grade and small sized potatoes. If such potatoes could be disposed of locally for feed, the marketing costs would be relatively small as compared with costs of commercial sales for human consumption. New sacks would not be needed for feed potatoes, and transportation and other handling costs would be greatly reduced. Also, they would serve as a cheap source of feed for livestock producers and thus be a benefit to both the potato and the livestock industries. Of more importance, however, such potatoes would not be competing with or replacing the merchantable grades in the table stock channels of trade.

The exact quantity of potatoes actually fed by livestock feeders each year is unknown. Since 1909, the Bureau of Agricultural Economics has made estimates of the quantities disposed of through feeding to livestock, shrinkage, and loss after harvest, but these three items have been estimated together.

Shrinkage and losses or waste probably make up the largest part of the estimate. However, it is well known that many farmers follow the practice of feeding the low grades and culls on the farm where the potatoes are grown. Table 1 shows, for the years 1937 through 1947, the estimated quantities of potatoes disposed of through feeding to livestock, shrinkage, and losses after harvest, the quantities of potatoes diverted to livestock feed through Government programs, and the estimated production of feed grains and hay in the United States.

Table 1.—Estimated quantities of potatoes disposed of through feeding to livestock, including shrinkage and losses after harvest, potatoes diverted from Government-owned stocks for livestock feed, and production of feed grains and hay in the United States, by years, 1937-1947

Year	Disposal of potatoes		Estimated production of —	
	Fed to livestock: shrinkage, and loss after harvest	Diverted to livestock feed from Government-owned stocks 1/	Feed grains	Hay
	1,000 tons	1,000 tons	1,000 tons	1,000 tons
1937	860	191	100,100	83,000
1938	896	-	96,800	91,400
1939	2/758	-	95,800	86,500
1940	897	225	98,600	96,100
1941	812	-	105,100	95,800
1942	707	-	120,800	107,700
1943	1,293	27	112,100	103,100
1944	742	6	116,700	102,700
1945	835	53	114,400	108,500
1946	905	588	124,400	100,700
1947	577	72	96,060	102,500
1948 3/	(4/)	5/131	132,900	97,700

1/ Not included in previous column.
2/ Includes 37,200 tons of early potatoes in California diverted from sales channels under provisions of marketing agreement.
3/ Preliminary estimates.
4/ Not available.
5/ As of August 16, 1948.

Compiled from reports of the Bureau of Agricultural Economics and records of the Production and Marketing Administration.

The volume of potatoes fed to livestock is dependent on several factors, such as the supply available for an extended feeding period, prices of the potatoes in relation to competing feed-stuffs, and transportation costs from the potato-producing area to the livestock-feeding area.

General Information on Feeding Potatoes to Livestock

No single commodity contains all of the necessary nutrients for the efficient feeding of livestock. Fresh potatoes contain about 21 percent of dry matter which is mostly starch. The high moisture content causes fresh potatoes to be more nearly comparable with such succulent feeds as corn ensilage, wet beet pulp, and wet brewers' grains, than with grain. Potatoes should be fed in combination with other feedstuffs to make a well-balanced ration. Table 2 shows the average composition of feedstuffs most commonly included in potato-feeding experiments.

Table 2.—Feedstuffs and potatoes: Average composition and digestible nutrients

Feed items	Total dry matter	Digestible protein	Total digestible nutrients	Nitrogen-free extract	Mineral matter
	Percent	Percent	Percent	Percent	Percent
Potatoes, fresh. .	21.2	1.1	17.3	17.4	1.1
Potatoes, meal . .	92.8	3.7	71.4	75.8	4.3
Corn, ensilage . .	28.3	1.3	18.7	16.5	1.7
Beet Pulp, dry . .	92.0	4.8	71.8	59.9	3.5
Beet pulp, wet . .	11.6	0.8	8.9	5.4	0.5
Beet tops, sugar	27.0	1.8	11.8	11.3	8.5
Alfalfa, all . . . analyses.	90.4	10.6	50.3	36.4	8.3
Clover hay, red in bloom	88.2	7.8	53.4	39.6	6.2
Timothy hay, full bloom . . .	88.7	3.2	48.0	44.8	4.8
Corn, dent, No. 2 .	85.2	7.1	80.6	68.4	1.3
Milo-grain. . . .	89.4	8.7	79.9	71.2	1.9
Cotton-seed meal 45 percent protein, and over. .	93.0	37.8	80.8	25.1	5.6

"Feeds and Feeding" page 953, 20th edition by F. B. Morrison, Cornell University, Ithaca, N. Y., and unpublished data by F. B. Morrison.

There are many formulas for calculating the value of a succulent feed. Assigning a monetary value is ofteh misleading as the prices of feedstuffs vary individually and collectively from time to time and the livestock feeder is always scouting the field to find the best "buy" for his feed requirements. However, the general farm operator needs a yardstick for determining the market price he can afford to pay for potatoes for livestock feed. Since the demand for potatoes is inelastic, potato growers often could afford to feed, or sell for feed, low-grade and surplus potatoes at an apparent loss and still increase total returns from potatoes.

According to Morrison and Turk (17) 2/ of Cornell University about 400 to 450 pounds of fresh potatoes are required to equal 100 pounds of an average grain mixture. Stated in another manner, potatoes are worth about one-fifth to one-fourth as much as an average grain mixture when fed in well-balanced rations. Cooked potatoes however, may be of greater relative feed value for feeding swine.

In terms of nutrients, potatoes are about equal in feed value to good corn ensilage or one-third the feed value of alfalfa hay. According to reports of experiments in Idaho, potatoes contain approximately twice as many digestible nutrients as wet beet pulp or beet tops (3). In feeding lambs, for example, 1 ton of potatoes replaced 562 pounds of alfalfa and 240 pounds of barley.

The comparative feed value of fresh potatoes may be computed as follows:

- 100 pounds of shelled corn equals 450 pounds of fresh potatoes.
- 100 pounds of alfalfa hay equals 300 pounds of fresh potatoes.
- 100 pounds of corn silage equals 100 pounds of fresh potatoes.
- 100 pounds of mixed grain equals 350 pounds of cooked potatoes when fed 2 to 1 with the grain, to swine.
- 28 pounds of alfalfa and 12 pounds of barley equal 100 pounds of fresh potatoes for lamb feeding.

2/ The underscored numbers in parentheses refer to Literature Cited, pages 43, 44, and 45.

Although it is comparatively simple to formulate a rough tabulation of comparisons in feed values, the establishment of cash values is difficult. Cash values for potatoes can be assigned as a percentage of the prices of the other feeds at the ratios shown in the above tabulation, but such values have real meaning only when computed on the basis of the feeds customarily used, and particularly on the basis of feeds for which potatoes are expected to be substitutes.

In addition, since fresh potatoes are bulky, any comparison of prices with other feeds should be based on the prices delivered at the feed lot. In other words, if it is necessary to truck both alfalfa hay and potatoes a distance of 100 miles, an allowance must be made for hauling 300 pounds of potatoes as against that for hauling 100 pounds of hay.

Most of the dry matter in potatoes is a good quality of easily digestible starch. Raw potatoes should not be used to replace all of either grain or hay in a ration because of the high moisture content and the laxative effect of potatoes when fed in excessive amounts. There is no hard and fast rule as to how much of the various feeds in a ration may be replaced by potatoes. For cattle, the rule is that potatoes may replace approximately one-half of the hay or all the ensilage or a small portion of the digestible nutrients in grain.

For all types of livestock except swine the best results can be obtained by feeding potatoes in fresh form. Cooking the potatoes improves their palatability and digestibility for swine, but there is no advantage in cooking potatoes for cattle, sheep, and horses. Since potatoes are perishable, the feeding periods in many areas are limited by warm weather. These periods can be lengthened by making ensilage of the potatoes, although ensilage contains slightly lower feeding value than fresh potatoes.

Caution: Although many millions of bushels of potatoes have been fed to livestock with very few reports of injurious effects, nevertheless there are some differences of opinion

on the toxic effects of sunburned, decomposed, sprouted, and frozen potatoes. These differences have been summarized by Beeson, Hickman, and Fourt (3) who state that "A number of writers have mentioned the poisonous material, solanin, which is regularly found in all parts of the tuber but in dangerous quantities only in green, or sunburned, potatoes and sprouts. Sprouting does not change the solanin content. Hansen reported cases of solanin poisoning and attributed it to some form of bacterial toxin instead of solanin, as he concluded that solanin was hydrolized. Holt reports yearling heifers died in a short time from potato poisoning when small potatoes containing many sunburned and green tubers were fed. Dice reported that cows were fed considerable periods on potatoes that were (a) partly decomposed, (b)sprouted, (c)sunburned, (d) that had been frozen and thawed out for short and long periods, (e) that were decomposed, sprouted, and sunburned, and (f) on potato sprouts, — but in no case did the animals show any evidence whatsoever of toxic symptoms from possible poisonous properties in the potatoes or potato sprouts, and only one case of slight digestive disturbance occurred." However, until further work is completed it appears unwise to recommend feeding decayed and sprouted potatoes. Frozen potatoes should not be fed.

To prevent digestive disturbances, fresh potatoes should be introduced into the rations gradually. If scouring occurs the volume of potatoes fed should be reduced, then gradually built up again until the desired maximum feeding quantity is reached. Occasionally, whole potatoes cause choking. This possibility may be eliminated by coarsely chopping the larger potatoes or by feeding under a bar so that the animal keeps its head down while eating.

Specific Feeding Data by Classes of Livestock

Dairy Cattle

In 1946 Morrison and Turk (17) of Cornell University stated that dairy cows may be fed 15 to 25 pounds of potatoes daily depending on the size of the animal. The cows should be started on smaller quantities to accustom them to eating potatoes. Best results were obtained when potatoes were fed with a legume roughage, such as alfalfa hay, as the high-protein alfalfa tended to balance the low-protein content of fresh

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potatoes. If corn silage and potatoes are to be fed, the total amount of the two combined should not exceed 3 pounds per 100 pounds of body weight of the animal. Since potatoes are low in phosphorous it is desirable to add 2 percent of steamed bone flour to the daily ration of grain mixture.

Considering the experimental data as a whole, it appears that potatoes can be fed safely in amounts not exceeding 35 pounds per head daily to cows weighing approximately 1,200 pounds. Larger amounts may cause digestive troubles. Potatoes may be substituted for all or part of the corn silage, or part of the grain mixture, with 4 to 5 pounds replacing 1 pound of an average grain mixture, or for part of the hay at the rate of 3 pounds of potatoes for each pound of hay (3).

An experiment with several types of potato silage and fresh potatoes was conducted at the Agricultural Research Center, U. S. Department of Agriculture, Beltsville, Md. in 1945, by Shepherd, Woodward, and Melin (18). Each type of silage was fed to four milking Holstein cows for 6- to 9-day periods to observe the relative palatability of the silages, as measured by total feed consumption, and the effect on live weight of the cows and on the quantity and quality of milk produced. The cows had been on rather poor pasture prior to the experiment but were kept off pasture during the potato silage feeding periods. The potato silage feeding trials were followed by four 6- to 9-day periods in which the cows were fed raw potatoes (one period), corn silage (two periods), and pasture with no silage (one period) in the order mentioned.

The average weight of the Holstein cows was about 1,400 pounds and they were producing 25 to 50 pounds of milk per day. The cows consumed from 52 to 56 pounds of the potato silage per day. When fed raw potatoes instead of silage, they consumed 79 pounds daily. They consumed more each day of each kind of potato silage and of raw potatoes than they did of corn silage, which indicated that all the potato feeds were palatable. The mucky condition and objectionable odor of the straight potato silage, potato and corn meal silage, and potato-salt silage apparently had little effect on the total consumption of these silages. However, they were consumed more slowly and with less apparent relish than were the potato-hay silages or the raw potatoes.

When the raw potatoes, potato silage, and potato-salt silages were fed, the total dry matter consumption was slightly less than when the potato-hay silages were fed. In each feeding period the cows consumed more digestible protein and total digestible nutrients than they required, according to Morrison's feeding standards (16). This excess consumption of feed nutrients no doubt accounted for the cows' gradual increase in live weight during the experiment. Table 3 shows the amounts of feed consumed, the production of milk and butterfat, and other pertinent data recorded during the experiment by Shepherd, Woodward, and Melin (18).

The average daily milk production per cow increased by about 6 pounds when the cows were changed abruptly from rather poor pasture to potato silage containing 22 percent hay. This level of milk production was maintained during the feeding period in which the ration contained potato and 20 percent hay silage. From this point there was a gradual decrease in milk yield with each successive silage feeding period except when raw potatoes were fed. The decrease in milk yield became slightly greater near the end of the experiment because of the advanced stage of lactation of the cows.

The average fat content of the milk decreased when the cows were changed from pasture to the potato and 22 percent hay silage, but the total quantity of fat produced remained practically unchanged. The average fat content remained at about the same level, fluctuating within a rather narrow range (3.09 to 3.26 percent) during the periods when potato silages containing 10, 15, 20, and 22 percent hay were fed. When the cows were fed the potato and 5 percent hay silage, the average fat content dropped to 2.92 percent. Following this, when the straight potato silage, the potato and 3-percent corn meal silage, and the potato with salt silage were fed, the fat content of the milk dropped still further (2.60 to 2.27 percent). During these periods the fat and fiber content of the ration also was low. The fat content of milk produced by other cows on other rations during the same period was not affected in a similar manner, which indicates that the changes were due entirely to changes in rations.

Table 3.—Live weight, production, and feed consumption of 4 Holstein cows on the rations indicated (average per cow per day) 1/

Feed fed in addition to hay and concentrates	Total length of feeding period	Live weight 2/	Production			Feed consumption			Dry matter consumed	
			Milk	Butterfat		Silage	Hay	Concentrates	In silage	Total
	Days	Pounds	Pounds	Percent	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Pasture		1,358	44.6	3.60	1.61		3/	13.2		
Potato-22% hay silage .	6	1,376	50.5	3.20	1.62	60.5	6.4	13.7	20.6	38.3
Potato-20% hay silage .	7	1,402	50.2	3.09	1.55	56.0	8.1	13.8	17.6	36.8
Potato-15% hay silage .	7	1,406	43.5	3.25	1.42	58.6	6.8	13.0	19.5	36.4
Potato-10% hay silage .	6	1,395	41.1	3.26	1.34	51.6	7.5	13.2	15.7	33.7
Potato-5% hay silage. .	6	1,391	41.6	2.92	1.22	56.6	7.7	13.4	18.3	36.6
Potato silage	9	1,393	38.3	2.60	1.00	53.0	8.3	13.8	16.4	35.8
Potato-3% corn meal silage	7	1,419	35.3	2.27	.80	58.6	8.2	13.8	18.6	38.0
Potato-0.75% salt silage	6	1,461	31.0	2.49	.77	51.8	7.2	12.1	17.9	34.8
Potatoes (raw)	9	1,424	32.6	3.02	.98	4/79.3	8.3	13.8	4/16.2	35.5
Corn silage	6	1,456	28.5	3.20	.91	45.8	7.1	13.8	15.0	33.4
Do.	6	1,461	27.7	3.66	1.01	48.0	8.7	13.8	14.5	33.7
Pasture	6	1,420	24.5	3.92	.96		8.0	8.5		

1/ Averages based on the fourth, fifth, and sixth days that the cows were on the respective rations.
2/ Differences in live weight may be due partly to differences in "fill."
3/ Cows had free access to hay.
4/ Raw potatoes

From Tech. Bull. No. 914, page 8, U. S. Department of Agriculture.

Changing from potato silage to raw potatoes caused an increase in the fat content, although there was very little increase in the fat and fiber content of the ration. The fat content of the milk continued to increase during the last three periods when corn silage and pasture were fed instead of the raw potatoes. The changes in fat content observed in this experiment (18), when potato silages containing little or no hay were fed, are similar to those observed in other experiments.

The milk produced when the cows were fed the different silages was scored for flavor and odor, 45 points representing a perfect score. When the cows were on pasture or were fed potato and hay silage containing a 10, 15, 20, or 22-percent proportion of hay, the milk scored an average of 40 points, which represents a good grade of commercial milk. When the silages containing larger amounts of potatoes were fed and when raw potatoes were fed, the milk was graded down slightly because of objectionable flavor and odor. The objectionable flavor and odor tended to persist during the first corn silage feeding period that followed the feeding of raw potatoes.

According to results of experiments in North Dakota, Dice (9) found it impossible to produce "potato flavored" milk by feeding potatoes, but when he stored cream in a potato cellar the butterfat absorbed such a flavor. In only one instance during the course of his experiment was the off-flavor of milk described as a "potato flavor." In 1924 Babcock (2) stated that he produced slight off-flavors in the milk of some cows by feeding potatoes 1 hour before milking but that no bad effects were observed when the potatoes were fed after milking.

In the experiments at the Idaho Agricultural Experiment Station, reported in 1935 by Atkeson and Anderson (1), butter made from milk produced by cows that were fed raw potatoes was equal in body, texture, and flavor to that produced by cows fed corn silage. Thus, it would appear that potatoes or potato silage fed in moderate amounts after milking would not affect the flavor or odor of the milk or the quality of butter produced from the fat.

In 1940 Beeson, Hickman and Fourt (3) found that milk and cream permitted to remain in an atmosphere heavy with potato odor tended to absorb some of the odor. It is, therefore, recommended that the feeding of potatoes to dairy cows should be accomplished after the milk has been removed from the barn.

Between August 1945 and April 1946 the county agricultural agents in 18 New Jersey counties conducted livestock feeding demonstrations, on 1,265 dairy and livestock farms, using a total of 1,666 carloads of surplus potatoes which were supplied by the U. S. Department of Agriculture. About 80 percent of the potatoes were fed raw, whole, or chopped, and the remaining potatoes were made into silage with corn or other roughages. Records and observations on feeding results were kept by the individuals who fed the potatoes. From the records and observations, 793 reports were made available. Most of the potatoes were delivered in good condition, although 50 farms reported them in poor condition on arrival. In some cases even the potatoes in good condition upon delivery did not keep well on the farms, but became soggy and spoiled rapidly. This was principally because of poor storage conditions on the farms and perhaps in part owing to the wet growing season and resultant poor storage quality of the tubers.

A total of 564 farms reported potatoes fed raw to a total of 17,808 head of dairy cows, 479 heifers, and 625 beef animals. The rate of feeding varied from 3 to 60 pounds, mostly 25 to 30 pounds, per head daily. Considerable variation in feeding practices on the various farms was reported. Some farmers fed the same rations as before the demonstration, except that they added potatoes to the regular ration. Others fed less grain, hay, or silage; still others omitted silage entirely.

Of the 648 dairy farms reporting, 323 stated that feeding whole or chopped fresh potatoes resulted in an increase in milk production, 274 indicated no change, and 18 reported a decrease in milk production. The rate of increase varied from "slight" to 15 percent. Thirty three reports contained no reaction on production.

Six hundred and twenty-five farmers reported on the physical condition of their dairy herds as affected by the feeding of potatoes. Two hundred and sixty-seven reported a condition ranging from a slight to a marked improvement, 343 reported no change, and 15 reported poorer condition. Cows on exceptionally good pasture, or fed liberally on other feeds of high quality, showed the least response to potatoes.

The chief complaints were that: (1) The cows were slow in developing an appetite for potatoes; (2) extra time was required for chopping; and (3) too much labor was required in handling the potatoes. Of 18,912 cattle that were fed potatoes, 3 animals choked to death on whole potatoes.

Some of the farmers ensiled the potatoes with green corn, dry corn fodder, sorghum, dry hay, or green soybeans. The silage was fed at a rate varying from 8 to 90 pounds per head daily, the most common rates being 20, 30, and 40 pounds per head daily, or just about the same as straight corn silage.

Through a cooperative agreement between the Texas Agricultural and Mechanical College, The Texas State Extension Service, and the Production and Marketing Administration of the U. S. Department of Agriculture, 60,000 sacks of surplus fresh potatoes from the 1947 crop were distributed for demonstrational feeding purposes, to 20 selected farmers in Texas. The farms were located in 20 different counties and varied in size and class of livestock fed, but in each case the potatoes were ensiled with dry hay, grain sorghum, or oat-straw. The Texas State Extension Service obtained reports from each of the 20 farmers on the results of their feeding tests. These reports showed that the percentages of hay or roughage included in the mixture varied from 5 to 53 percent. A 20-percent hay and 80-percent potato mixture was used in most instances.

Nineteen of the feeders' reports indicated that potatoes and hay were run through ensilage cutters to obtain the mixture. One farmer chopped the potatoes and spread alternate layers of hay and potatoes in the silo.

All the farm feeders reported favorably on the feeding of the potato ensilage. Two farmers reported excessive shrinkage from water drained off, but they thought that more hay ensiled with the potatoes would have materially reduced this shrinkage. All the farmers reported that potato silage and roughage mixtures were palatable and readily consumed by cattle. The animals fed the potato silage included the following: 846 dairy cattle, 518 beef cattle, and 12 horses.

Only one cow was reported as refusing to eat the potato silage, but 28 other dairy cows on the same farm increased their milk production by 20 percent. Of the 20 demonstrational feeders 11 reported increases in daily milk production ranging from 8 to 20 percent. Some of the feeders estimated dollar gains, both from the milk increase and from the savings in feedstuffs which they

would have had to purchase had potatoes not been available.

One farmer fed 120 dairy cows for 180 days on a ration containing potato hay silage and figured a gain of $3,700—resulting from a 20-percent increase in milk production. Another farmer with 100 dairy cows figured a saving of 1½ tons of hay per day for 100 days. He valued the hay at $1,500. In addition his cows gave an extra 30 gallons of milk per day.

Five farmers reported no gains in milk production but stated that production was maintained at August and September levels during the late fall and cold winter months. Two farmers reported excellent gains in feeding beef cattle, and two others had not opened their silos at the time of their reports.

In 1947, feeding tests with rations including dehydrated potatoes were conducted at the University of Maryland. Dairy rations included 15 percent, 20 percent, and 25 percent of dehydrated potatoes in mixtures of grain, soybean meal, cottonseed meal, and molasses. In all rations tested the dehydrated potatoes mixed well and proved to be quite palatable to the animals. However, the ration containing 20 percent of dehydrated potatoes was most readily consumed by the animals. The physiological condition of the animals remained good throughout the tests and no scouring or bloat occurred.

The full effects on milk flow were not recorded in these tests; however, it was noted that production was sustained and no odor or change in the quality of the milk was apparent.

Beef Cattle

Potatoes are sometimes used in the fattening ration and may be used in a wintering ration for beef cattle. Potatoes may replace part of the grain and hay, if fed in a balanced ration containing alfalfa hay and grain. The steers should be started at a rate of about 3 to 4 pounds of potatoes daily per animal, and the ration may be gradually increased to 20 pounds, varying according to the feeding capacity of the steers. When added to alfalfa hay and ground barley each ton of potatoes—as reported in the Idaho experiments in 1940 by Beeson, Hickman, and Fourt (3) — replaced

906 pounds of alfalfa and 186 pounds of barley. The addition of silage to an alfalfa and barley ration increased gains 14.6 percent and the addition of potatoes increased gains 20.3 percent. In three Colorado experiments in 1945 and 1947, reported by Connell and co-workers (4), (5), and (6), potato and corn fodder silage showed a feed replacement value equal to corn silage which had been supplemented with cottonseed meal. Potato silage had a greater feed replacement value than corn silage which had not been supplemented with cottonseed meal. In these experiments,heifers fed potato and corn fodder silage made greater gains than did those fed corn silage.

In one of the Colorado experiments (6), conducted in 1945, one lot of steers received potato and corn fodder silage and the other lot received potato and alfalfa hay silage. These two lots of steers produced more rapid gains at a lower cost than did the check lot which received straight corn silage. The potato silages each averaged more than twice the food replacement value of corn silage in this experiment. Potato and alfalfa hay silage produced slightly better gains than did the potato and corn fodder silage. Heifers fed cooked potato silage made good gains, but there appeared to be no advantage in going to the extra expense of cooking the potatoes for cattle.

As compared with ground corn, dehydrated potato meal appeared to be almost as palatable and produced slightly higher gains in an experiment reported in 1944 by Strong (21) of Kern County, Calif. In another experiment (5) dehydrated potato meal proved to be practically equal to corn in feeding value and showed a slightly higher value than did dried beet pulp. In Colorado experiments (4),(7), the feeding value of dehydrated potato cubes and dried beet pulp, in a feeding ration for steers, was equal to ground No. 2 corn.

Tables 4, 5, and 6 show the rations fed and other pertinent data relative to the Colorado experiments in the feeding of potatoes to beef cattle.

In a feeding test conducted by a commercial feeder in Kern County, Calif., in 1939, one lot of 12 heifers was fed barley, cottonseed meal, alfalfa hay, and corn silage and for the second lot all the barley in the ration was replaced with sun-dried potato meal. The average daily gain was practically the same for both lots. The potato meal was fed at the rate of 9 pounds per day.

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Table 4.--Comparative average daily gains of calves and yearling heifers on fattening rations containing potatoes, potato silage, cooked potato silage, and other feeds, 1925, 1930-31, and 1944

Feed items	1925 calf rations (daily) containing mostly --			1930-31 calf rations (daily) containing mostly --			1944 yearling-heifer rations (daily) containing mostly --			
	Corn silage	Potatoes	Potato silage	Alfalfa	Potatoes	Corn silage	Alfalfa hay and corn silage	Alfalfa hay and cooked potato silage	Corn silage and alfalfa hay	Alfalfa hay and cooked potato silage
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Rations containing										
Barley	6.9	6.9	6.9	6.1	4.5	4.5	5.5	5.5	6.0	6.0
Cottonseed cake. . . .	- -	- -	- -	1.0	1.0	1.0	.9	.9	- -	- -
Linseed meal	1.0	1.0	1.0	- -	- -	- -	- -	- -	- -	- -
Potatoes	- -	9.0	- -	- -	16.4	- -	- -	- -	- -	- -
Corn silage.	9.2	- -	- -	- -	- -	15.6	6.8	- -	6.9	- -
Alfalfa hay.	4.9	6.7	6.7	11.0	7.6	4.3	7.2	7.6	6.6	8.1
Dehydrated potatoes. .	- -	- -	- -	- -	- -	- -	5.5	5.5	6.0	6.0
Potato silage.	- -	- -	7.4	- -	- -	- -	- -	- -	- -	- -
Cooked potato silage. .	- -	- -	- -	- -	- -	- -	- -	6.5	- -	6.6
Average daily gain per animal	2.10	2.09	2.16	2.03	1.97	1.98	2.53	2.39	2.18	2.44

Compiled from data in table 4, page 11, of Tech. Bull. No. 37, Colorado Agricultural Experiment Station, Colorado Agricultural and Mechanical College, Fort Collins, Colo.

Table 5.--Comparative average daily gains of calves, yearling heifers, and steers on fattening rations containing alfalfa hay, potato corn fodder silage, potato alfalfa hay silage, and other feeds 1930-31, 1944, and 1945.

Feed items	1930-31 calf ration (daily) containing mostly --			1944 yearling heifer ration (daily) containing mostly--			1945 yearling steer rations (daily) containing mostly--		
	Alfalfa hay	Potato-corn fodder silage	Corn silage	Alfalfa hay and corn silage	Alfalfa hay and potato-corn fodder silage	Alfalfa hay and potato-alfalfa hay silage	Ground corn	Ground corn and potato-corn fodder silage	Ground corn and potato-alfalfa hay silage
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Rations containing:									
Ground corn	- -	- -	- -	- -	- -	- -	14.5	14.5	14.8
Ground barley	6.1	4.5	4.5	5.5	5.5	5.5	- -	- -	- -
Dried potatoes.	- -	- -	- -	5.5	5.5	5.5	- -	- -	- -
Cottonseed cake	1.0	1.0	1.0	- -	- -	- -	- -	- -	- -
Cottonseed meal	- -	- -	- -	0.9	0.9	1.0	1.0	1.0	1.0
Potato-corn fodder silage.	- -	15.6	- -	- -	6.9	- -	- -	4.3	- -
Potato-alfalfa hay silage.	- -	- -	- -	- -	- -	6.9	- -	- -	4.4
Corn silage	- -	- -	15.6	6.8	- -	- -	4.4	- -	- -
Alfalfa hay	11.0	5.4	4.3	7.2	7.0	8.2	3.8	3.7	4.0
Average daily gain per animal.	2.03	1.99	1.98	2.53	2.53	2.54	2.11	2.23	2.37

Compiled from data in table 5, page 13, of Tech. Bull. No. 37, Colorado Agricultural Experiment Station, Colorado Agricultural and Mechanical College, Fort Collins, Colo.

Table 6.--Comparative average daily gains of yearling heifers and steers on fattening rations containing dry beet pulp, dried shredded potatoes, dried cubed potatoes , and ground corn, 1944, 1945, and 1946

Feed items	1944					1945		1946	
	Yearling heifer rations (daily) containing mostly --					Yearling steer rations (daily) containing mostly --			
	Corn silage and alfalfa hay	Corn silage	Alfalfa hay and dry beet pulp	Alfalfa hay and dried shredded potatoes	Alfalfa hay and corn silage	Ground corn	Dried shredded potatoes	Ground corn and dry beet pulp	Dried cubed potatoes and dried beet pulp
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Rations containing:									
Ground corn	5.8	5.8	- -	- -	5.5	14.5	- -	7.7	- -
Rolled barley	- -	- -	5.5	5.5	5.5	- -	- -	- -	- -
Dried shredded potatoes .	- -	5.8	- -	5.5	- -	- -	14.9	- -	- -
Dried cubed potatoes. . .	- -	- -	- -	- -	- -	- -	- -	- -	7.8
Dry beet pulp	5.8	- -	5.5	- -	- -	- -	- -	7.7	7.8
Cottonseed meal	1.0	1.0	0.9	0.9	0.9	1.0	1.0	0.5	0.5
Corn silage	7.3	7.3	6.9	6.8	6.9	4.4	4.4	6.0	6.0
Alfalfa hay	7.0	6.7	7.6	7.2	7.2	3.8	4.0	4.3	4.2
Average daily gain per animal	2.22	2.31	2.44	2.53	2.41	2.11	2.25	2.57	2.54

Compiled from data in table 6, page 14, of Tech. Bull. No. 37, Colorado Agricultural Experiment Station, Colorado Agricultural and Mechanical College, Fort Collins, Colo.

In tests on feeding dehydrated potatoes to beef animals at the University of Maryland three lots of steers were fed from October 1, 1947 to May 2, 1948. One lot was a check lot which received barley, soybean oil meal, and clover-timothy mixed hay. The other two lots were fed similar rations except that one-third of the barley was replaced with dehydrated potatoes for one lot, and dehydrated potatoes replaced one-half of the barley for the other lot. All the animals made satisfactory gains and their carcasses graded Choice with the exception of one which graded high Good.

The results of these tests indicate that dehydrated potatoes can be used to replace one-third of the grain ration for fattening steers when the price relationship of grain to potatoes is favorable. One third of the grain replaced with dehydrated potatoes gave the best feeding results and the highest gains (fig.1). Some scouring was experienced in the lot where one-half the grain was replaced with dehydrated potatoes.

Figure 1.—Hereford steer finished out on a ration in which one-third of the grain was replaced with dehydrated potatoes in feeding tests conducted at the University of Maryland.

In another test at the University of Maryland, the feeding of dehydrated potatoes in the winter rations of breeding stock proved satisfactory. Two to four pounds of dehydrated potatoes were added as a supplement to corn silage and mixed legume hay.

It was concluded that the feeding value of dehydrated potatoes appears to be about equal to that of barley.

In addition to the results of the tests at the University of Maryland, large numbers of feeders have been observed, in recent years, feeding cull potatoes at a much higher daily rate than is ordinarily recommended — even as high as 75 to 100 pounds of potatoes per head daily. Rations containing large quantities of potatoes usually include increased quantities of dry hay, and salt and other minerals, but decreased quantities of grain.

Sheep

According to experiments conducted in Idaho (3), fresh potatoes are well adapted for use as a part of the ration both for fattening lambs and for wintering ewes. For fattening lambs, potatoes should be fed, at the rate of 1 to 2 pounds daily per lamb — 2 pounds daily being considered a full feed — with good quality legume hay and grain. The potatoes may be fed either whole or chopped. Potatoes were found to be equal in feed value to corn silage for fattening lambs, and they appeared to be more valuable as a succulent feed than carrots or cull apples. Fed in small quantities, 1 ton of potatoes replaced 562 pounds of alfalfa and 240 pounds of barley in the rations of lambs in the experimental lot. The lambs in this lot were all thrifty and well finished. Frozen, sprouted, green, or decayed potatoes should not be fed to sheep and, during extremely cold weather, all refused potatoes should be removed from the feeding troughs within a short time after feeding, to prevent the lambs from eating frozen potatoes. In some cases, it may even be advisable to discontinue the feeding of potatoes until the weather moderates.

In Colorado experiments (12), (4), reported in 1946 and 1947, lambs were fed cubed and shredded dehydrated potatoes and dried beet pulp along with a grain misture. In one lot, dried cubed potatoes constituted the ohly concentrate in the ration. As compared with whole corn the dried cubed potatoes fed alone produced 7 pounds more gain per lamb during the 84-day feeding period, and the consumption of the cubed potatoes and the alfalfa hay was lower per hundred pounds of gain in comparison with the lot receiving corn. In this test, based only on one lot of lambs for 1 year, the cubed potatoes proved to be worth one-third more than whole corn. The rations fed to fattening lambs and the average daily gains in weight are shown in tables 7, 8, and 9.

Table 7.--Comparative daily gains of lambs on fattening rations containing potatoes, potato silage, and other feeds, 1925 and 1931

Feed items	1925 lamb rations (daily) containing mostly —					1931 lamb rations (daily) containing mostly —				
	Corn silage	Alfalfa hay and potatoes	Alfalfa hay and wet beet pulp	Alfalfa hay	Alfalfa hay and potato silage	Wet beet pulp	Alfalfa hay and potatoes	Alfalfa hay	Alfalfa hay	Alfalfa hay and potatoes
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Rations containing:										
Shelled corn. . .	1.0	1.0	1.0	1.0	1.0	- -	- -	- -	- -	- -
barley	- -	- -	- -	- -	- -	0.8	0.8	0.9	0.9	0.8
Cottonseed meal. .	- -	- -	- -	- -	- -	- -	- -	- -	.2	.2
Potatoes (raw) . .	- -	1.9	- -	- -	- -	- -	1.4	- -	- -	1.4
Wet beet pulp. . .	- -	- -	2.0	- -	- -	4.4	- -	- -	- -	- -
Corn silage	1.8	- -	- -	- -	- -	- -	- -	- -	- -	- -
Potato silage . . .	- -	- -	- -	- -	1.8	- -	- -	- -	- -	- -
Alfalfa hay	1.7	2.1	2.5	2.7	2.2	1.9	2.4	2.5	2.3	2.2
Average daily gain per animal	0.31	0.34	0.32	0.31	0.37	0.31	0.31	0.29	0.30	0.29

Compiled from data in table 7, page 16, of Tech. Bull. No. 37, Colorado Agricultural Experiment Station, Colorado Agricultural and Mechanical College, Fort Collins, Colo.

Table 8.-- Comparative average daily gains of fattening lambs on rations containing potato-alfalfa hay silage, potato-corn fodder silage, wet beet pulp, and grain, 1931 and 1945

Feed items	1931 lamb ration (daily) containing mostly --						1945 lamb ration (daily) containing mostly --			
	Alfalfa hay	Alfalfa hay and potato-corn fodder silage	Alfalfa hay	Alfalfa hay and potato-corn fodder silage	Wet beet pulp	Wet beet pulp	Ground alfalfa and corn silage	Ground alfalfa and potato alfalfa hay silage	Wet beet pulp	Ground alfalfa
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Rations containing:										
Ground corn	- -	- -	- -	- -	- -	- -	0.4	0.4	0.4	0.4
Whole barley. . . .	0.9	0.8	0.9	0.8	0.8	0.8	- -	- -	- -	- -
Rolled barley . . .	- -	- -	- -	- -	- -	- -	.5	.5	.5	.5
Cottonseed meal . .	.2	.2	- -	- -	.2	- -	- -	- -	- -	- -
Wet beet pulp . . .	- -	- -	- -	- -	4.4	4.4	- -	- -	3.0	- -
Potato-corn fodder silage.	- -	1.4	- -	1.4	- -	- -	- -	- -	- -	- -
Potato-alfalfa hay silage.	- -	- -	- -	- -	- -	- -	- -	1.3	- -	- -
Corn silage.	- -	- -	- -	- -	- -	- -	1.2	- -	- -	- -
Ground alfalfa . . .	- -	- -	- -	- -	- -	- -	2.4	2.3	2.7	3.1
Alfalfa hay.	2.3	1.7	2.5	1.7	1.5	1.9	- -	- -	- -	- -
Average daily gain per animal	0.30	0.31	0.29	0.28	0.34	0.31	0.30	0.33	0.38	0.31

Compiled from data in table 8, page 16, of Tech. Bull. No. 37, Colorado Agricultural Experiment Station, Colorado Agricultural and Mechanical College, Fort Collins, Colo.

Table 9.--Comparative average daily gains of fattening lambs on rations containing dried beet pulp, dried potatoes, and other feeds, 1945 and 1946.

Feed items	1945 lamb rations (daily) containing mostly --			1946 lamb rations (daily) containing mostly --					
	Ground Alfalfa and dry beet pulp	Ground alfalfa and dried shredded potatoes	Ground Alfalfa	Ground Alfalfa and dried beet pulp	Ground alfalfa and dried shredded potatoes	Ground alfalfa	Ground alfalfa and dried cubed potatoes	Ground alfalfa and dried cubed potatoes	Ground alfalfa and whole corn
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Rations containing:									
Dried shredded potatoes. .	- -	0.4	- -	- -	0.6	- -	- -	- -	- -
Dried cubed potatoes. . .	- -	- -	- -	- -	- -	- -	0.6	1.3	- -
Dried beet pulp.	0.4	- -	- -	0.6	- -	- -	- -	- -	- -
Whole corn	- -	- -	- -	- -	- -	- -	- -	- -	1.1
Ground corn.	.2	.2	.4	.3	.3	0.6	.3	- -	- -
Rolled barley.	.3	.3	.5	.3	.3	.6	.3	- -	- -
Ground alfalfa	2.8	2.9	3.0	2.5	2.6	2.6	2.6	2.5	2.4
Average daily gain per animal	0.31	0.29	0.31	0.40	0.37	0.32	0.39	0.43	0.34

Compiled from data in table 9, page 19, of Tech. Bull. No. 37, Colorado Agricultural Experiment Station, Colorado Agricultural and Mechanical College, Fort Collins, Colo.

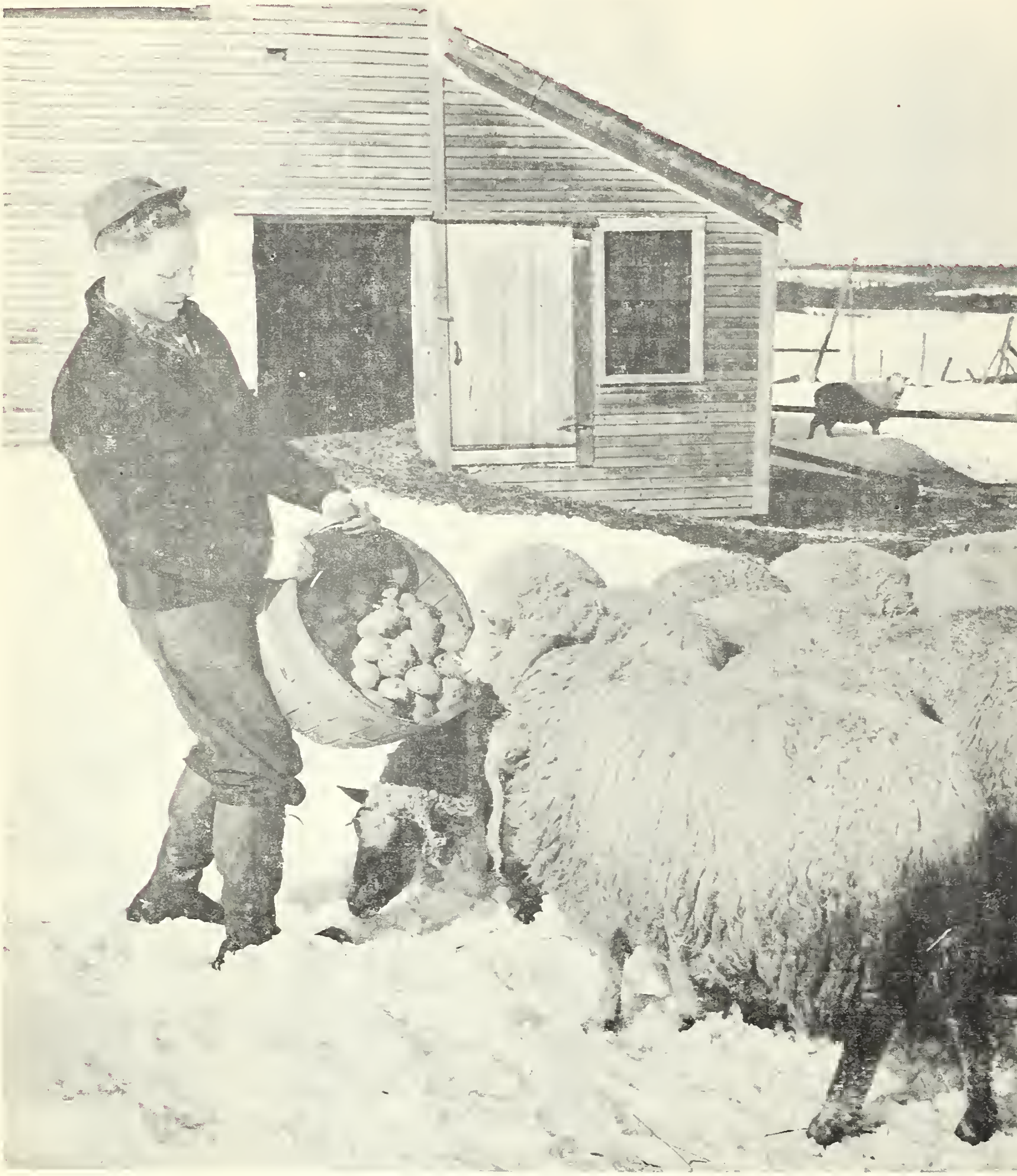

Figure 2.— Some of Maine's surplus potatoes being fed to sheep in the winter of 1947.

In wintering pregnant ewes, potatoes may supply a portion of the ration. From 2 to $2\frac{1}{2}$ pounds of potatoes daily in combination with alfalfa hay should be considered the maximum feed for ewes up to lambing time. Feeding larger quantities of potatoes may result in weak lambs, primarily because of mineral deficiencies in the ration. After lambing, the potatoes may be increased to 4 pounds per ewe daily, without detrimental results. Unofficial reports from individual commercial feeders indicate that the addition of potatoes to the ration of ewes immediately following lambing increases lactation to such an extent that fewer lambs are lost. The improved physical condition of the ewes results in healthier lambs. Some feeders claim that they feed potatoes to sheep as a general practice (fig. 2). It is always well to keep in mind that when potatoes are fed, good quality alfalfa or some other feed must make up the bulk of the ration in order to supply the protein, minerals, and vitamins necessary for reproduction.

Swine

Cooked potatoes make an excellent feed for swine. Cooking increases the digestibility of potatoes and improves the palatability for these animals. Raw potatoes are worth only one-half to two-thirds as much as cooked potatoes for swine (3). Potatoes may be steamed, for about 30 minutes, in large kettles or in a covered dump truck. The steamed potatoes may be stored in a silo without adding any other material. For best results the cooked potatoes should replace not more than one-half of the grain ordinarily fed in the ration. They may be fed at the rate of 2 to 4 pounds of potatoes per pound of grain, with a maximum of 4 pounds of potatoes to 1 pound of concentrate. About 425 pounds of cooked potatoes are required to replace 100 pounds of grain, when not more than 3 to 4 pounds of cooked potatoes are fed with each pound of grain. If 2 pounds of cooked potatoes are fed with each pound of grain, then 350 pounds of potatoes will equal 100 pounds of grain. Potatoes should be fed in a well-balanced ration containing an ample protein supplement and minerals. Table 10, compiled from the Colorado experiments (4), shows the rations used in feeding raw potatoes, cooked potato silage, and dehydrated potatoes for fattening pigs.

North Dakota experiments (14) indicate that dehydrated potatoes may be used to replace up to one-half of the corn or other grain in a properly balanced ration for feeding pigs. In balanced rations, dehydrated potatoes have a feed value comparable with that of the common grains used for feeding pigs.

Table 10.--Comparative average daily gains of pigs on fattening rations containing raw potatoes, cooked potato silage, dried potatoes, and other feeds, 1930, 1930-31, and 1944

Feed items	1930 pig ration (daily) containing mostly —		1930-31 pig ration (daily) containing mostly —		1944 pig ration (daily) containing mostly —					
	Barley	Barley and raw potatoes	Barley	Barley and raw potatoes	Ground corn	Potatoes	Cooked potato silage	Cooked potato silage and ground corn	Dried potatoes	Ground corn and dried potatoes
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Rations containing:										
Potatoes (raw). . . .	- -	0.3	- -	0.6	- -	11.6	- -	- -	- -	- -
Cooked potato silage.	- -	- -	- -	- -	- -	- -	16.5	6.0	- -	- -
Dried potatoes. . . .	- -	- -	- -	- -	- -	- -	- -	- -	3.6	.9
Ground Corn.	- -	- -	- -	- -	5.0	- -	- -	4.0	- -	4.2
Barley	4.7	4.9	5.2	4.6	- -	- -	- -	- -	- -	- -
Field peas (hogged down) . .	.05	.05	.05	.04	- -	- -	- -	- -	- -	- -
Tankage.	.3	.3	- -	- -	- -	- -	- -	- -	- -	- -
Soybean meal	- -	- -	- -	- -	.7	.7	.7	.7	.7	.7
Alfalfa meal	- -	- -	.06	.04	.04	.05	.06	.05	.06	.05
Average daily gain per animal	1.22	1.32	1.15	1.13	1.42	.52	.95	1.48	.55	1.36

Compiled from data in table 10, page 21, of Tech. Bull. No. 37, Colorado Agricultural Experiment Station, Colorado Agricultural and Mechanical College, Fort Collins, Colo.

As reported by Strong (21), several Kern County, Calif., farmers fed sun-dried potatoes—without grinding or cooking—to hogs (fig. 3). These California experiments indicate that the starch granules in sun-dried potatoes change in appearance and become similar to those in the starch found in cooked potatoes. Apparently, the ground temperatures in the San Joaquin Valley during July and August are high enough to bring about this change in sun-dried potatoes during the drying period.

Figure 3.—Hogs feeding on whole potatoes that were sun dried before being dumped into the hog lot.

Other Types of Livestock

Available data are insufficient to make definite recommendations regarding the feeding of potatoes, in either fresh or dehydrated form, to other types of livestock. However, individual reports indicate that good results were obtained in feeding potatoes to fatten turkeys and other poultry. Producers of laying hens are cautioned against unsatisfactory results from any sudden changes in rations. One ration for poultry that has come

to our attention is that found in a German publication from the Agricultural and Bacteriological Institute, Friedrich-Wilhelms University, Breslau, Germany (20). This ration contained 10 pounds of meat scrap, 10 pounds of middlings, 20 pounds of bran, and 40 pounds of cooked potatoes.

German experiments (11) indicated that raw potatoes compared favorably with oats when fed to horses at the rate of 3 pounds of potatoes to 1 pound of grain. The 3 pounds of potatoes were supplemented with 1 ounce of soy-bean meal. Working horses and mules may be fed up to 12 pounds of potatoes per 1,000 pounds of live weight of the animal. The inclusion of 3 to 5 pounds of potatoes in the daily rations of horses and mules appears to improve their physical condition and to be generally beneficial, as potatoes have a tonic, laxative, and appetizing effect. Potato silage also may be fed in small quantities, but it must be free from spoilage, mold, and freezing damage.

Storage and Preservation of Potatoes for Feeding Purposes

Feeders of most classes of livestock generally desire to maintain a steady supply of a particular feedstuff for several weeks; therefore, the storage of potatoes may present a real problem. Fresh potatoes must be protected from extremes of both heat and cold. The ideal method of feeding potatoes would be the hauling of the fresh potatoes directly from the storage or packing shed to the feed lot but this is not always practicable. The potatoes may be stored fresh, ensiled, sun-dried, or mechanically dried. The most economical method in each instance must be determined by the potato grower or the livestock feeder.

Storage of Fresh Potatoes

Storage of potatoes in fresh form is recommended in areas where such storage is practicable. This method is most economical in that it conserves the labor and cost of processing, and the fresh potatoes have a slightly higher feeding value on a dry weight basis than do processed potatoes. Adequate storage space for fresh

potatoes usually is available to livestock feeders in late potato-producing States. However, the feeders in early and intermediate crop producing areas, and in some locations in the late crop States, are not so fortunate and some form of preservation or processing is needed.

Potato Silage

Experiments conducted at Beltsville, Md., in 1945 proved that potato ensilage containing 20 percent or more of dry hay makes a palatable, nutritious feed for dairy cows. This ensilage was eaten with more relish and maintained milk production better than did straight potatoes or potato silage containing very little hay. Furthermore, the loss of feed nutrients from the potatoes was lowest in the silage containing the most hay.

Various mixtures of potatoes with other feeds have been tried throughout the country. The Colorado Experiment Station (4) found that 16 to 20 percent of corn fodder or alfalfa hay made an excellent silage. Morrison (16) recommends the addition of 2 percent of corn meal to inoculate the mass with lactic acid bacteria. The corn meal, or any other grain product including whole grain, may be mixed with the potatoes prior to the ensiling process (fig. 4).

The usual method of mixing potatoes with other feeds at the time of filling the silo is to run the potatoes and roughage through the ensilage cutter at the same time (figs. 5 and 6).

According to an experiment in California (21), alternate layers of chopped potatoes, barley hay, and molasses, ensiled in a trench silo made an excellent feed. Hay comprised about 20 percent of the ensilage.

Figure 4.—Potatoes for the ensilage cutter, showing the mixing of grain before adding the roughage in the cutter trough.

Figure 5.—Ensilage cutter, showing the method used in mixing potatoes with dry stover.

Figure 6.—Ensilage cutter, showing the mixing of potatoes with green corn.

Ensiling of potatoes with not less than 20 percent dry hay or stover offers an economical method of preservation. Practically all forms of silos have been used for potato ensilage. The one factor of primary importance is drainage. The less dry stover or hay ensiled with the potatoes, the more important is the drainage factor. Potatoes contain a high percentage of moisture. A high percentage of potatoes in the mixture increases the weight of the ensilage per cubic foot, thereby exerting great pressure on the silo walls. Splitting of the walls may occur. For this reason, as much dry roughage should be added in permanent silos as will be needed to absorb the excess moisture in the potatoes and lessen the pressure against the silo walls. This would require about 600 to 700 pounds of dry hay or dry corn fodder for each 2,000 pounds of potatoes. The quantity used should be estimated closely, since an excessive amount of dry roughage might make the silage dry enough to produce mold. As an added precaution against silo failure it would be best to fill the silo not more than two-thirds full.

In addition to the cylindrical above-ground type of silo, other types used are pit silos, trench silos, and temporary silos constructed of picket fences with a lining of sisal kraft paper.

Temporary silos may be utilized on farms where the permanent cylindrical types are not available. The trench types are probably the most efficient of the temporary silos (fig. 7).

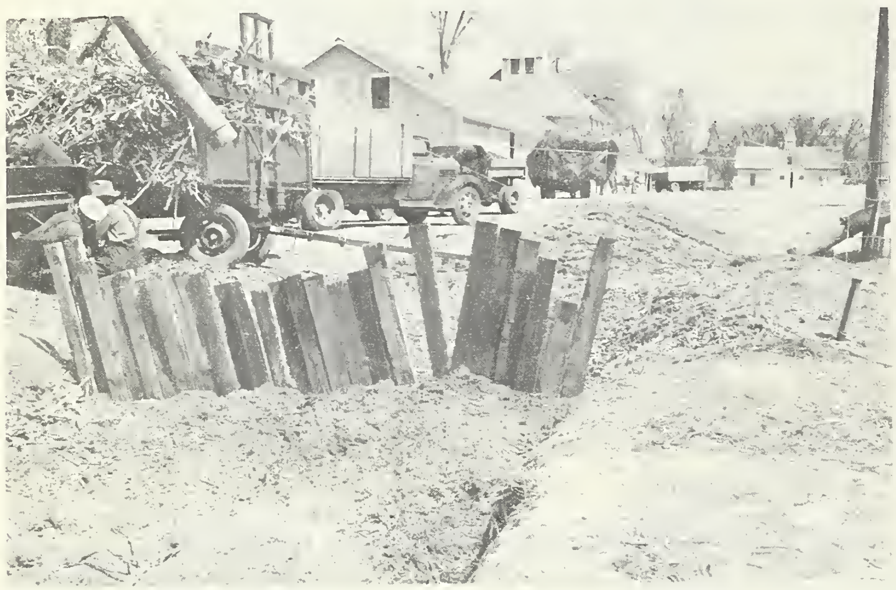

Figure 7.—Trench silo, showing a partition for the purpose of dividing different types of ensilage.

Above ground fence and stack types of silos are recommended only in cases where large quantities of ensilage products are available and for areas where underground drainage is a problem.

According to McCalmont (15) of the U. S. Department of Agriculture, the trench silo may be constructed to any size. A trench 10 to 12 feet wide and of approximately the same depth is usually excavated on a gentle slope. Tile or pipe drains may be run from the bottom level of the silo off the side of the hill to provide efficient drainage. If the ground where

the trench is to be dug is nearly level, tile or pipe drains may be led into the pit near the silo base. Drainage is important, not only because of silage preservation, but as an added convenience after the trench is opened for feeding. Natural rainfall may collect in the trench at the end opened for feeding. If an underground drain is not provided, the feeder must resort to bailing or pumping. Surface water should be ditched around and away from the silo. The walls of the silo should be as nearly vertical as possible. A slight slope to the walls may be necessary to prevent crumbling. The amount of slope depends largely on the soil structure. Trench silos have been constructed with walls ranging from vertical to 45 degrees of slope. Walls with more than 5 inches per foot of slope from vertical should be reinforced with cement plaster, rock, or some other type of material. The cost of this lining may be too expensive for a temporary silo. Once the trench is complete, the ensilage may be packed by driving livestock through the trench or by driving a caterpillar tractor of farm size over the ensilage as filling takes place. A layer of straw and dirt, 6 to 12 inches in depth, will form an effective seal and cover. Feeding should take place from the end, only such portion of the ensilage being uncovered as is necessary (fig. 8).

Figure 8.—Shallow trench silo opened at one end.

In areas where drainage is difficult, and plenty of ensilage products are available, temporary fence silos may be

constructed. A circle of snow fencing or 2- by 4-inch mesh, welded steel wire may be set up on level ground. The inside of the fence should be lined with paper. All kinds of building and roofing papers, with and without fibrous reinforecement may be used. Reinforced papers give better results. The paper may be held to the fence by the use of clothespins or by two wooden slats—one long and one short—nailed together at one end to form an elongated clothespin. Lined silo walls maintain less spoilage than unlined walls. The average loss from spoilage is about 8 inches from the lined wall as compared with about 10 inches from the unlined wall.

The first section of the silo should be filled to within about 6 inches of the top before attachment of the second section. Each additional section should be tied about every 18 inches to the next lower section and the paper lining should be placed on the inside of the next lower section to prevent tearing as the silage settles. Where snow fencing is used, the outside of each section should be reinforced with No. 9 wire pulled taut by the use of turnbuckles. From two to four strands of No. 9 wire tier are usually sufficient to hold the picket fence type of silo together. However, as the height of this silo increases, more wire may be necessary to confine the unusual weight at the base. A desirable height is three to six tiers. In general the height of a fence silo should not exceed its diameter. If another tier is placed on the silo, additional reinforcements, such as posts or guy wires, may also be necessary.

Stack silos are often used in emergencies. Baled hay—reinforced by tying the bales together and setting posts in the ground as braces—may be used. The size of the stack silo will depend on the amount of feed to be ensiled. The larger stacks lessen the percentage of spoilage losses, since spoilage occurs generally around the outside walls. The stack should be packed as tight as possible to exclude air. It is best to feed from this type of silo by slicing off one end rather than by removing top layers.

Cooked potatoes also may be ensiled. The water from the cooked potatoes should be drained off before the mass is dumped into a trench silo. If potatoes are to be cooked before ensiling, cooking should continue until a large percentage of the tubers crack open. No mention is made in any of the experimental results available, of other feeds being ensiled with cooked potatoes. The cooked potatoes—usually cooked in a dump truck with steam pipes laid on the floor of the truck body—are dumped

into a trench silo and sealed with top layers of straw and dirt (fig. 9). Feeding of the cooked potatoes may start at once (fig.10).

Figure 9.—Dump truck, showing the connecting steam pipes for cooking potatoes. The tarpaulin aids in cooking the top layers.

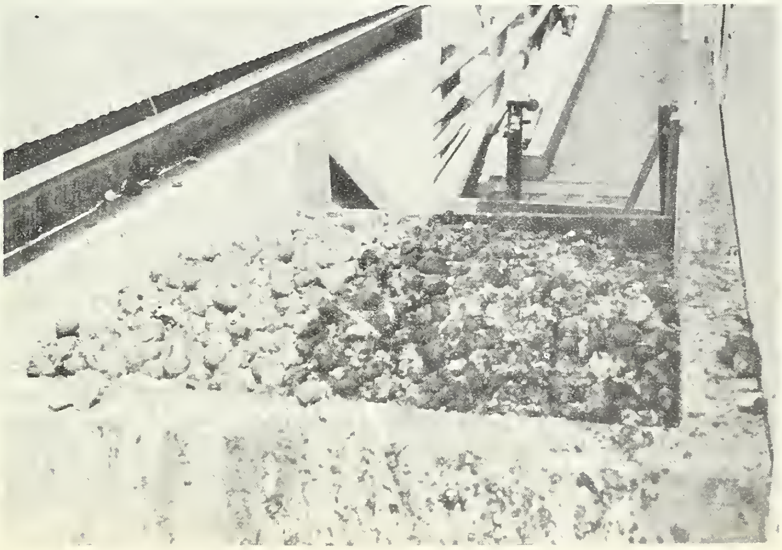

Figure 10.—Concrete vat of cooked potatoes which were stored before feeding.

Sun Drying of Potatoes

During the last few years, the practice of sun-drying whole potatoes has been followed in California (21). The potatoes are spread on fields during June, July, and August. From 60 to 90 days are required to complete the natural drying process for whole potatoes (fig. 11). The dried product is ground into a meal and and may be fed in a mixed ration, or separately, as part of the daily ration.

Figure 11.—Whole potatoes spread on the ground for sun drying.

In 1941 according to Stafford (19), potatoes were cut and spread over a field covered with straw mulch for air drying. The recovery amounted to 450 pounds of dried product per ton of raw potatoes. One batch of potatoes dried sufficiently for grinding into meal after 6 days. Ideal weather conditions and the fact that the potatoes were chopped before spreading on a dry straw, speeded up the evaporation of moisture. The potatoes may be spread on macadam or concrete air strips (as was done in 1946),

rolled down with a heavy road roller, and stirred or turned daily to speed up the process of drying. The usual length of time for drying to the milling stage in this case is 1 week.

In areas where the relative humidity is low and temperatures range from 60° upward, sun drying of potatoes should be successful. Whole potatoes may be spread on clean fields to depths of from one layer to 8 inches. Chopping and periodic stirring speeds up the drying process (fig. 12).

Figure 12.—Chopped potatoes that were sun-dried on the ground in California, July 1941.

Drying Potatoes by Alternate Thawing and Freezing

Potatoes of the 1946 crop were dried successfully on the ground in open pastures in North Dakota during the winter months of 1947. The quantity of the dried product recovered and the quantity of raw potatoes spread on the fields were not reported. It is known, however, that many tons of potatoes were spread on open pastures and subjected to alternate periods of freezing and thawing throughout the winter months. The potatoes became dry or mummified. It is reported that beef cattle on one farm gained 2.07 pounds per day for 72 days while grazing on good pasture and consuming the dried potatoes.

A small sample of the potatoes dried or mummified by the above method was submitted to the Agricultural Research Administration's Eastern Regional Research Laboratory at Wyndmoor, Pa., for chemical analysis. Comments from the Laboratory were as follows:

"The skin of the potatoes, as submitted to us, was very hard and dark in color, but the body of the potato was quite light in color. There was a slight putrefactive odor which became more noticeable on grinding. But while the odor persisted in the whole potatoes, it practically disappeared from the ground potatoes after a few days."

The analysis showed that the potatoes dried by this method contained 17.1 percent moisture and 82.9 percent solids. Protein content of the sample analyzed was negligible. The moisture content of this sample was probably too high for safe storage. The dried potatoes in the sample were picked up in June from fields on which potatoes had been spread in February 1947, and the unusually wet spring in the Red River Valley may have accounted for this high moisture content. Additional experimental work is needed to determine the practicability of this method of drying.

Other Methods

Other methods of preservation of potatoes include all the accepted methods of mechanical dehydration. Dehydrated potatoes have not as yet been widely adopted as stock feed. The under-

lying reasons are probably explained by the relatively small supplies available and the high cost of plant operations. However, experimental runs are continuing and dehydrated potato stock feeds may increase considerably within the next few years.

In attempts to discover a drying process for potatoes that would involve less cost and enable the manufacturers to compete in commercial markets with handlers of other feeds, several experiments have been conducted by State experiment stations, State colleges, and feed manufacturers in cooperation with the Department of Agriculture. Beet pulp drying plants in Nebraska have dried potatoes with some success. Processors of brewers' grain have dried potatoes for mixing with their feed products. Plants constructed for the purpose of drying citrus pulp and vegetable by-products have been successful in the drying of potatoes. However, as a rule it has been found that operating costs are prohibitive in plants that have successfully produced dried potato feed products. Several plants have made changes in their machinery and operation in an effort to lower costs. Other processors have dried potatoes only as a fill-in operation during slack period of drying other commodities for which their plants were established.

Research Projects Contemplated and in Progress

Virginia Truck Experiment Station

In July 1948 the Virginia Truck Experiment Station conducted an experiment in sun drying of potatoes at Melfa. The objective of this experiment was to test the practicability of sun drying potatoes on an air-strip in an area of high relative humidity. In the past, it had been common belief that drying of potatoes to 10 to 12 percent moisture content could not be successfully accomplished in the East because of the frequent rains, the high moisture content of the air, and the average low velocity of the winds. The Virginia Truck Experiment Station officials undertook the task of disproving this theory.

A cutting machine powered by a small gasoline engine of less than one horsepower was constructed by machinists at the Experiment Station. A drum roller of concrete with a center shaft and pulling attachment was also constructed. The drum weighed approximately 1,000 pounds.

On completion of the machinery, 1,700 sacks of potatoes were delivered to the air-strip. One batch of potatoes was spread on the concrete to a depth of about 3 to 4 inches. The drum roller was then pulled over the potatoes in an attempt to crush them. This method proved ineffective. Over half of the potatoes were only slightly cracked. Those that were crushed made a watery mass that promptly began to rot.

A second batch of potatoes was then run through the machine cutter. The cut potatoes were spread in a thin layer from $\frac{1}{2}$ to 1-inch thick and were dried to approximately 15-percent moisture content in 3 days. From approximately 5,500 pounds of raw potatoes, about 1,000 pounds of dried material was recovered. One rain fell on this particular batch of potatoes while they were spread on the concrete surface. The rain fell during the night just prior to the third day of drying. By midafternoon the product was dry again and crackled like breakfast food underfoot.

Another batch of potatoes treated similarly dried to approximately 13-percent moisture content in a period of about $4\frac{1}{2}$ days.

The secret of success in this drying experiment proved to be that of expeditious handling. Potatoes that have been cut so as to provide the maximum of starch exposure should be spread immediately in a thin layer to obtain maximum air circulation. Moreover, they should be picked up as soon as they are dry.

Plans have been made for individual farm feeding tests of the potatoes dried in this experiment. Farmers in the area of the air-strip have been asked to feed the dried product on their farms and to report the feed value for whatever class of livestock they may desire to feed.

U. S. Department of Agriculture

Officials of the Department of Agriculture are now studying the possibilities of further sun-drying experiments in the eastern seaboard potato producing areas. Drying tests on air-strips in Virginia, New Jersey and on Long Island, N. Y. were started in August, 1948. The preliminary results were very successful in spite of the late start and a considerable amount of rain and high humidity.

Nebraska Agricultural Experiment Station

The Nebraska Agricultural Experiment Station and the U. S. Department of Agriculture made a cooperative contract July 20, 1948, for conducting experimental tests pertaining to sun-drying of potatoes for livestock feed at an air-strip near Grand Isle, Nebr.

The first test included 8,000 pounds of potatoes of the Red Warba variety. Of these potatoes 4,000 pounds were spread on a smooth concrete surface and crushed with a tractor-drawn corrugated roller, and the remaining 4,000 pounds were cut into slices 1/8 inch to 1/4 inch in thickness, then spread on the concrete surface about 2 inches deep.

The crushed potatoes started fermenting immediately and continued fermenting for 48 hours. Although drying of this batch of potatoes was finally completed, much of the feed value of the crushed potatoes had been lost.

The sliced potatoes began drying immediately, without any apparent fermentation. They dried into a much brighter, more attractive appearing product than did the crushed potatoes. The 1/4-inch slices had a brighter appearance than did the 1/8-inch sliced potatoes.

All potatoes on the air-strip were stirred twice daily throughout the drying period, July 22 to 27, 1948.

Good drying weather prevailed, with practically no rainfall throughout the testing period.

On July 27, 1948, a second test was started with 10,000 pounds (100 sacks) of U. S. No. 2 Red Warba potatoes. The 1/4-inch slice was used on this lot.

About 3,000 pounds had been cut and spread when a 1.4-inch rain fell, on July 29. The remaining 7,000 pounds were cut and spread after this rain. Drying progressed satisfactorily and the potatoes were almost dry enough to take in when a period of damp weather started, on August 2, and continued through August 3. The potato slices seemed to absorb large quantities of water, but were drying again without serious loss or damage at the time of this report.

Test lots of 10,000 to 18,000 pounds per week will be delivered for drying on this air-strip until approximately 108,000 pounds of potatoes have been used. The Nebraska Agriculture Experiment Station officials will make a final report on the data obtained in the experiment at a later date.

Producers and feeders are watching the development of this new source of livestock feed with interest. Private sources estimate that 15,000 tons of feedstuffs are shipped into the potato-producing areas of Nebraska annually. If all the cull and low-grade potatoes produced locally were converted into a staple livestock feed product, by sun-drying on an air-strip, one-third to one-half of the deficit in feedstuffs could be supplied at much lower cost than that of other feeds at the present level of prices. It was estimated by private interests that dried potato feed could be produced from culls and low grades at present costs, and sold profitably at $35 to $40 per ton of dried product.

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